ONTARIO DEPARTMENT OF EDUCATION

CURRICULUM P1, J1

INTERIM REVISION SCIENCE

1967

SCIENCE – INTERIM REVISION

This booklet is issued so that schools may continue to develop their science programs, pending the report of the Provincial Committee on Aims and Objectives. The interim revision presents new approaches to science and new resources which may serve to enrich programs in current use.

These interim courses are published for *study*, for *discussion*, and for *optional implementation* in part or as a whole.

In the development of this outline, invaluable assistance was received from many individuals and groups. Comments and suggestions will be welcomed; the revision of curricula is a continuing process.

CONTENTS

PREAMBLE

This interim revision is intended to consolidate the good practice of the present day so as to pave the way toward future science programs. Some teachers have already adopted the proven practices of their colleagues and some have developed new approaches in intuitive fashion. Some have tested out the wealth of resources in methods and materials that have been produced by science groups in recent years. As well as being ready to teach science in new ways, teachers have been receptive to new thought in the whole field of education. In such a climate of change, this updated program is designed to prepare the way for further advances.

Although this interim revision may facilitate eventual major change in the teaching of science, its main purpose is to identify and record what shows most promise in current practice and thought.

As a preliminary step, the programs of study that had been developed in many localities of Ontario were examined. Visits were made to schools, and experiments in science curricula in Ontario and elsewhere were studied. The study revealed the strong features of present courses, and those units of newly developed experimental programs in which some topics were treated with new effectiveness. At this stage consultations were arranged with persons in schools, in colleges, in administrative positions, in science research groups, and in the wider community. Through criticism and advice, an approach to science was formulated which appeared productive and viable.

The timing for the development of a new approach proved fortunate, for many curriculum resources had been recently produced, and were becoming available. Most important, these new resources, listed in Appendix A, are compatible with one another, because they have many common characteristics. Further there is some agreement on approach.

First, there is agreement that every child learns best when real things, such as magnets, minnows, melons and mica, are at hand on which to base his inquiries. Books, films, radio, and television enhance, but cannot replace activities with real things.

Second, there is agreement that the experiences of the young child as he attempts to find things out are often more important than what he discovers. There are many ways of inquiring into the nature of things, and the more opportunity each child has of pursuing investigations in diverse ways, the richer his experience.

Third, there is general agreement that the learning of facts does not constitute an education in science. With the rapid expansion of knowledge, there is little hope of learning more than a small part of the information available. With the rapid changes in science and technology, there seems no certainty that any specific group of items of fact is essential to an education. What seems worth developing is some organization of knowledge, some conceptual scheme that appears reasonable to the child.

Two further premises underlie this updated approach to science: first, that the interests of individual children and groups of children should determine their activities in science as much as is feasible, and second, that the role of the teacher is to support with wise planning the child's endeavours to understand the nature of the world. For, if the child has an inner urge to discover things and a strong motivation to work at science, and if the teacher provides the framework for inquiry, a satisfactory program is possible.

A program designed to encourage free inquiry need not be disorganized. Without organization there might be unnecessary repetition and children might lose the chance to sample a diversity of topics. Each course has a simple plan in which a dozen or more topics are listed for each year. From these or others, some ten may be selected. The teacher, by his initial selections, plots the development of the science program according to the needs and interests of his class.

Once a topic has been chosen, a starting-point can be devised. Usually this is an idea, an event or an object. Suppose the topic 'Rain' has been chosen. Out in the rain some pupils might make measurements on the size of raindrop marks on the pavement. Later others might learn to record rainfall. Others might search meteorolo-

gical records, compute averages, and make graphs. At times class instruction would be essential; at other times group work would be more fruitful. The investigation would broaden out freely according to the interests of the children. As the work progressed, the pupils would express their findings in words, numbers, graphs, sketches, or three-dimensional structures. In the whole venture, the pupil's initiative finds its complement in the teacher's support.

Normally the science program will vary from class to class. Indeed to some extent, each individual child will have his own program. Since it is agreed that the experiences during inquiry are of major importance, and that science should not be limited to any one specific body of knowledge, a diversity of activities and findings is guaranteed. Hence, the individual child and the individual teacher in the individual school are largely able to determine their own programs.

The resources needed to support a modern science program are increasing year by year. Many teachers improvise and develop their own stores of equipment. Groups of teachers and special committees ensure that new ideas and devices are known to their fellow teachers. Skilfully planned units, carefully thought out manuals and monographs, reference books, and packaged apparatus provide patterns for activities. These resources can give guidance and inspiration, without limiting the independence of the classroom teacher.

The science program in a school remains viable so long as children have opportunity for direct inquiry, independent study and creative activity. In seeking these three for each child, we should avoid the hazards of inflexible programs. When a course is designed by the teacher for the boys and girls actually in his trust, a maximum of satisfaction and achievement becomes possible.

How can these achievements be evaluated? Pupils, parents, and teachers are naturally concerned that there be satisfactory progress in science. Children wish to be assured that their performance lies in the direction of the goals that have been set. Their parents want evidence that their children are learning. The teacher wishes to measure how successful he is in achieving his hopes for his pupils.

The evaluation of learning is a continuous process. First, the children express their findings everyday. As their teachers watch the results of investigations, the sketches, the comments, the written work, and other evidence, an estimate of progress is possible. These products indicate to parent and teacher what is being learned.

Second, by observing the children at work, and by listening to them, their teacher can assess their skills. For example, he can find how well they are able to make careful observations and to make inferences.

If groups of pupils are engaged in a diversity of activities, uniform science examinations may prove impractical, and if, in any case, a teacher is sensitive to the development of each pupil, and to his accomplishments, there is limited need for formal term tests or annual examinations.

Detailed suggestions which might guide the updating of science programs of the early school years may be found elsewhere in this booklet. No attempt has been made, however, to produce definitive courses, since there is no certainty that any specific elements of science are essential in the education of school children who will be living into the next century. Nor is there certainty that any one prescription for the teaching of science will best serve the needs of all children, and the community in which they live. Rather, the opportunity is presented to incorporate some of the new resources in science into present school programs.

INTRODUCTION

'The school is, on my view, simply a point of vantage for the child in his efforts to understand the real world, and to adapt himself to it. It should be a place of shelter for him; but not in the sense that it shuts the larger world away from him. Its task is to bring the world to him, in ways, and at a pace fixed by his needs and interests.'

Susan Isaacs
(From *'Intellectual Growth in Young Children'*)

1. Science in the school provides the child with an opportunity to explore the real world around, the world of technology as well as the world of nature. Already he has learned much, and at school he continues to ask questions and look for answers.

2. Little is excluded from his exploration, for the young child does not recognize traditional subject boundaries. Neither does he care that there is a body of organized knowledge and that learning can be sequential so that the understanding of one concept assists in the learning of another. The matter for inquiry consists of whatever interests him in the learning environment at the time – raccoons or rocks, candles or compasses, dandelions or dinosaurs.

3. The teacher can widen the child's interests by arranging for a stimulating school environment. The real world of the twentieth century is a joy to the child, and the school serves as a doorway to reality. Much of the world can be brought inside the walls of the school through books, magazines and newspapers, specimens, pictures, equipment and visual aids. More of the world remains outside, and the teacher who leads children into the world beyond classrooms walls provides a richer starting-place for science.

4. Science at school is science for children, not necessarily the conventional science of adults. With increasing knowledge of how children develop, it is becoming more nearly possible to suit education to the individual child at every age. Teachers no longer use the same methods with eleven-year-olds as with eight-year-olds. While most children over eleven are able to do abstract thinking with some facility, younger children think better when they are handling concrete materials. These children, in a sense, think with their hands. Most children under seven are still groping to understand the world around them, and probably in these early years the richest practical experiences should be arranged.

5. Through the years, children will have opportunities to practise the methods of science. These methods, and the attitudes of the scientist seem natural to young children as they explore their environment. Children are curious, they are observant, they ask questions, they seek answers in books and in practical activities, and they are critical of what they discover. Children, like scientists, must find things out in their own way.

6. This process of seeking answers, the process of inquiry, is the essence of science. The experiences of the child are more important than the product of these experiences. One could tell a boy that his shadow would be shortest at noon, and he would know it. But if another pupil traced out the boy's shadow on paper at nine o'clock, cut it out and repeated the procedure every hour till dismissal, and the whole array of cut-outs were fastened to a wall, questions would arise. The reason for the shortening and lengthening might be considered the product of the inquiry, but this product constitutes only a small part of the total experience. How pupils learn things is more important than the things they learn.

7. Younger children profit most when science is not treated as a separate subject, and even with older children it should not be treated in isolation.

8. The findings of the pupils represent much thought and effort. These products of inquiry, while not as important as the process of inquiry, are the bricks from which a structure is built. Facts themselves are of limited importance, but children are seldom satisfied until they have organized the facts into patterns. Because the child can find an orderliness in nature, his world becomes understandable. Year by year the child's concept of the world around him becomes more sophisticated. Eventually it resembles in some degree a scientist's conceptual scheme. This product of many inquiries has considerable importance.

9. Through a series of insights, a child slowly learns the nature of things. Ideally, he would choose his own starting-point for inquiry. In this syllabus certain items are proposed as 'starting-points' (see the example on pages 22-25). The teacher with his broad background, will have acquaintance with the organized knowledge that has accumulated about these items or topics. As he wishes the pupils to make their own discoveries, he will leave them free to make inquiry, giving encouragement, but only a minimum of direction. Using materials, apparatus, books, and audio-visual devices they will form their own ideas. Little by little, they will develop a degree of understanding of the fragment of the universe they study. Each child adds to what he already knows, and clearly each child may achieve a different degree of understanding.

10. The teacher's intention is to encourage each child to find out what he can. In doing this he should not set any limit on what the individual child may achieve. From a starting-point, the child can progress as far as time, resources, and interest allow; to ensure this a precise definition of content is avoided in the syllabus.

11. At times children may be encouraged to find things out very much on their own, with little guidance. At other times more definite procedures will be recommended by the teacher to guide them toward their discoveries.

12. A major role of the teacher is to arrange for working-time, to provide a stimulating environment, to let children ask their own questions, to encourage them to experiment in small groups or individually until answers are found that satisfy them. The teacher's role is more to guide than to direct.

13. When a pupil has discovered something, he will usually want to communicate his findings. The teacher's role at this stage is to provide a diversity of materials, so that each pupil will choose the medium that will express his discovery in a satisfying way. Sometimes he will prefer to use the written word, sometimes the spoken word. He may choose to paint pictures or build structures at a bench. On occasion he will make graphs and express his findings with numbers. This creative activity is the tangible product of direct inquiry and independent study. His creations are the evidence of his exploration of the real world.

Since these creations are his representation of the world as he sees it, the teacher will not expect complete accuracy in sketches and graphs, or faultless written work. Rather he will look for a child's honest expression of his own activities, up to his competence.

14. Although the syllabus suggests themes that might be chosen in successive years, the arrangement of times and topics is open to much modification. If a teacher finds a continuing interest in a topic such as "Space vehicles", he might encourage study of the same topic year after year at levels of increased sophistication. Further when a teacher knows the individual members of a school community well, he can devise sequences of activities in which the increased difficulty matches the increased abilities of the children. Thus a teacher may plan that some topics in the curriculum recur annually, even though the topics are not repeated in the printed syllabus. What matters is that a teacher continues month by month to provide rich and stimulating surroundings so that each child may have a unique experience as he finds patterns in things and events.

COURSES

‘OBSERVING FAMILIAR THINGS’ – FIRST YEAR

The years when the child is beginning school life are years different in many ways from the later ones. During these early years, the community is ready to grant him the privilege of living as a child. Teachers expect him to think as a child, not as a small youth nor as an immature adult.

The pre-school child has learned much already. Relatively he has learned more in a shorter time than he ever will do again. He has done it by eagerly exploring his environment.

His curiosity remains the starting-point for science in its widest sense, and the school allows him to continue this process in a more organized way. It should provide places and things to be explored, materials for making things, opportunities for planning, and even the chance to learn from mistakes. It should provide time for observing things, time for enjoying new sensations, time for conversation with other children and adults, time for tinkering and even ‘time to stand and stare’. In short, the experiences provided must be adequate, unrushed, and, above all, enjoyable.

SYLLABUS

To the child, the things around him form a new world. Some things in the world he has already observed many times, and these familiar things of the kitchen, the house, the yard, the street, and the school he will meet again and again. It is this nearby segment of the world that forms the first vehicle for science. The many familiar things that can be readily procured form starting-points for activities.

Each class can make its own list of familiar things. Some items will be included because children have asked questions about them. Some will be added because the teacher foresees interesting activities linked with specific real things, such as a study of the shape, function, and properties of a float. Some will be the articles found on the short trips in the school grounds, on nearby streets, and in parks. Some items may originate in other subject areas, such as social studies and mathematics. Some may be part and parcel of an integrated program.

These familiar things are the starting points, from which questions can arise which in turn will lead to activities. The finding-out activities comprise the science program. Here is part of a list compiled in one classroom:

Alarm clocks
Apples
Aquaria
Asparagus
Asphalt
Balls
Beans
Bicycles
Bird-feeders
Bolts
Bottles
Bouquets
Bread
Bricks
Buds
Butter
Cages
Candles
Carpets
Carrots
Cats
Chairs
Cheese
Cloth
Concrete
Corn
Crocuses
Crockery
Dishes
Dogs
Eggs
Eggbeaters
Elastic
Evergreens
Flashlights
Floats
Flours
Foodstuffs
Forks
Fruits
Funnels
Furs
Gadgets
Garden produce
Glue
Goldfish
Hamsters
Hinges
Hotplates
Houseplants
Ice
Ice cream
Jelly moulds
Kitchenware
Kites
Ladles
Lenses
Levels
Locks
Lumber
Magnets
Meatgrinder
Metals
Milk
Minnows
Mirrors
Nails
Narcissus

THE INTEGRATED PROGRAM

In some schools, science is included in an integrated program. Such integrated programs are a natural fusion of several subject areas. In classrooms adopting such a program, children have excellent opportunities ‘to observe familiar things’.

For example, suppose a class has visited a firehall. The occasion embraces experience in language, art, social studies, and mathematics, as well as science. Where an integrated approach has been used, one might find children building a fire station using blocks, controlling the water running through a garden hose by

means of a tap, making paper cut-outs of a fireman's clothing, playing out the activities at a fire or suggesting experiences to be written on experience charts. No boundary can be found between science and the other subjects.

SCIENCE BEYOND THE CLASSROOM

Frequent visits to the world around the school are essential. To provide some framework for such visits, one special area for field work is proposed for each school year. The area close to the school is suggested as the logical place for the pupils of this age.

Familiar things that are encountered on visits to places in the school grounds, in nearby streets, parks and establishments, might form part of a list. If the area is completely built up, man-made structures and machines can be observed. Such abundant materials as bricks and mortar show great differences to the eye and hand. But science is not limited to inanimate things. Even in downtown areas, many plants and animals may be found. Ventures into the world outside the classroom are often the most productive starting-points.

SUGGESTIONS

1. As much as possible, let the work follow the interests of the pupils. Children work best at self-appointed tasks (See the example in Appendix B).

2. As many senses as possible should be used.

3. As many similar situations as possible should be devised. For example, rather than examine one type of flour he should see several, and make observations on several.

4. At first, pupils should handle the materials without being given directions. Pupils are more creative and venturesome if given time to tinker while they find things out for themselves. Time, much greater in amount than is commonly allowed, should be devoted to free and unguided exploratory work. The teacher's role *in this phase* is to move from group to group, being helpful but refraining from prompting or directing.

5. Listening to children is essential. The teacher who listens to their questions and statements is able to assist them to gain understanding.

6. If necessary, provide suggestions that will allow pupils to explore aspects that may lead to interesting discoveries. Language, including conversation with adults, clarifies the child's experience and points the way ahead. Plan to have time for discussion.

7. In this syllabus, the 'familiar thing' being observed is the starting-point for an inquiry that will lead eventually to scientific concepts. But the emergence of concepts should be a natural process extending over many years. Teachers should neither give too much help nor urge conceptualization unduly, lest inquiry become stifled.

8. Children should represent their observations as freely as possible. What they have observed can be put in some external form, such as a drawing, a painting, or a model; or it can be expressed in conversation, writing, action, or song. Doing so, pupils experience their findings a second time in a new form. (Keeping a notebook is not recommended in the early years. Class scrapbooks make a more suitable record.)

9. The development from each starting-point can be expected to be different for each class. Therefore, no attempt is made here to suggest the science that may emerge from the various items.

In one school, each child was asked to bring a bottle, and a large collection of bottles of all sizes, colours, and shapes was soon assembled. The children filled some with water, and poured the water from one bottle to another. Many questions arose:

Which holds the most?
Which is shortest?
Where do the bubbles come from?
Why does everything look wavy through them?
What makes the 'pop' when the cork comes out?

These questions led to some original activities. One pupil used the smallest bottle as a unit of height and found that the tallest bottle was seven times as high. Others filled a larger bottle with water and poured the water into a smaller bottle to see how much bigger the first one was. Some found out that it was quite difficult to pour water into a bottle with a narrow neck, and to pour the water out again. Sometimes answers were found. Sometimes the answers waited for another day.

'EXPLORING THE CHANGING ENVIRONMENT' – SECOND YEAR

Some familiar things, such as flour and flashlights, remain unchanged over a long time. Others, such as dandelions and dew, change in a short time. The program in the second year is built around those things which are different at different times. It is a study of events.

In this course the young child has the opportunity to explore his environment from day to day as the seasons change. Some events, such as the disappearance of frost in sunlight, take only a few minutes. Others, such as the development of the buds, take months. To the teacher this is not new. He can predict many events of the year. But the changing year is a novelty to children of this age. Many observations, many questions, many activities, and some answers follow its study.

The basic theme of seasonal change should not be interpreted in a narrow and restrictive sense. The syllabus must be a flexible one. Among the events of the year will be many events not linked with the seasons, and having little to do with weather, animals and plants. For example, power lines may be newly strung near the school. This event may foster a beginning in a study of electricity. If the smoke of burning leaves fills the air in the autumn, a beginning in the study of combustion is desirable.

Most of the topics in the syllabus are closely related to the biological sciences. However, for the study of the events of the year, the physical sciences also are involved. For example, the inquiry into the problem, 'Where is dew formed?', provides activity and insight into several fields. On a trip outside, pupils may find that dew is formed on grass, but not on sidewalks, in the shade, but not in sunlight. This may lead to further questions, 'When is dew formed?' and 'Why does it form?' all leading to concepts of a water cycle, and of changes in temperature.

SYLLABUS

Pupils should have some share in choosing topics for their study. From the hundreds of events of the year, the teacher and class will be able to make a selection of topics. Activities can then be planned. Naturally the selection of one class will be somewhat different from the selection made by other pupils. Therefore, any list in a printed syllabus should be regarded as suggestive, not prescriptive.

The problems listed can be starting-points for inquiry, and are not in themselves the questions that pupils will ask. For example, the problem 'How fast does grass grow in spring?', can best be answered by outdoor work involving measurement of grass in selected spots from day to day. If differences in the rate of growth are observed, the question 'Why?' will follow.

Lists of suggested problems make up this syllabus. Those listed are sample problems from which a selection may be made; different ones might be devised with any class. The teacher's task is twofold: to ensure a wide selection of problems, and to encourage direct inquiry in solving them.

LATE SUMMER

Where are the warm spots outside the school?
What are the tallest flowers near the school (or what are the tallest farm crops)?
What flowers last longest in water?
Which wild flowers have the most seeds?
Where is dew found?
How many birds can be seen near the school at this season?
Which trees change colour first?
What changes does one's shadow have during a day?
How long is one's shadow at noon in late September?
How is one of the local farm crops harvested?

AUTUMN

What garden plants have leaves that freeze first?
What garden plants have leaves that freeze last?
What colours are found in tree leaves?
How long does it take till all the leaves have fallen from a tree?
What birds come to feeders in the fall?
How is the classroom heated?

How does the temperature outside change from day to day?
How does the length of one's shadow change from month to month?
When does the first snowflake fall?
What animals are still around outside after the first snowfall?
How do puddles freeze?
What happens to bulbs in the weeks after they are planted?
What happens to apples that are stored in a place that is not cool?
What changes take place in potatoes that are left in a warm room?

WINTER

How do icicles form?
Are twigs alive in winter?
What frozen plants can be gathered in winter?
What tracks are visible in the school yard?
Which is the shortest day of the year?
Why are storm windows used in winter?
Why do some people prefer pine trees as Christmas trees?
How do Christmas tree lights work?
How deep are drifts after a snowstorm?
Does the depth of snow change from day to day?
Under the snow, what is alive?
How wet is snow?
How do people prepare for winter?
How do farm animals survive the winter?
What kind of snow is best for skiing?
How does a sleigh work?
What kind of ice is best for skating?
When do the buds of poplars begin to swell?

SPRING

Where does one find the last snow?
What are signs of spring?
What birds arrive early?
When do birds sing most?
How long is one's shadow in late March?
What seedlings grow quickest in flats and gardens?
How are young farm animals different from older ones?
When are toad tadpoles first seen?
How fast does grass grow in spring?
How many small animals can you find in a quarter of an hour?
How does a farmer cultivate a garden or a field?
Why does a gardener pull weeds from a flower bed?
How does the temperature change during a day?
What animals live in shallow puddles?
When do trees leaf out?
What plants flower early in the spring?
Of what use are curbs and gutters along streets?
When does most water run off in the spring?
What animal calls and other sounds can one hear outside the school?

EARLY SUMMER

Does it get dark at the same time every night?
Where do birds, such as robins, build their nests?
How rapidly do young toads grow?
In what ways are young trees different from older ones?
At what rate do farm crop seedlings grow?
What changes take place as grass is harvested to form hay?
How can one tell if the wind is blowing?
What does a wind vane show?
What animals do you find underground when you dig?
How long is one's shadow in late June?
Where are the cool areas outside the school?

FIELD AREA

Since the program in this grade is so closely linked to nature study, a great many of the observations will be made out-of-doors near the school. To collect information, frequent field work will be essential. Sometimes the whole class, and at other times a small committee, or a single pupil can gather the data.

Further, special field work is proposed for children of this age – a carefully planned visit to a farm. A visit at any season will give insight into rural activities. Conversely, it is usually possible for rural children to make a visit to a town to observe the characteristics of the built-up areas.

SUGGESTIONS

Many of the suggestions for the development of the First Year apply to the theme 'Exploring the Changing Environment.'

1. Observation and description of events can be recorded in many ways. Some teachers encourage a day-to-day class record, rather than individual notes in books.

2. Much information can be recorded in graphical form. Depth of snow, for example, can be represented by strips of paper, by broken straws or by lengths of string.

3. Wherever possible, mathematics, science and social studies, and literature should be linked.

4. Many children will now be able to read reference books. Provide a choice of books so that a child can find the help he needs.

5. Children in this age are not mature enough to stick to any topic for a long time. Pace the problem-solving according to the interests of the pupils.

6. As children develop different interests in their environment, devise ways by which they can work best. Some children at some times prefer to work alone; at other times they may work with another

pupil or in small groups. In pursuing problems, diversity of grouping is usually possible.

7. Measure the success of the science program by what the individual child does every day. The teacher who listens to the young child and who watches him make inquiry will have no need to apply testing procedures.

8. Where few farms are within visiting distance of the school, teachers could adapt the program. In communities where one large industry predominates, such as the production of pulp and paper, the activities of this industry throughout the year could replace the farm-based items.

9. Many of the children will be writing with difficulty. The formation of letters and spelling of words should be a matter of less concern than the ideas that are put on paper.

10. Many activities will start out-of-doors and be continued in the classroom where pupils can work more effectively.

In one school, the teacher asked: 'What tracks can you find in the school yard today?' This led far. First, each child went outside to examine the animal tracks; many became interested in their own tracks. Back in the school, a search began for books that would contain sketches of the snow-tracks of mice and cottontails. Pictures and paper cutouts were produced of the tracks of the wild animals, and dog tracks were later found in abundance. Several children began to record their own footprints. Some traced the shape of their shoes on cardboard; some attempted to chalk the soles so that a coloured print could be made on construction paper. One who remembered an incident from 'Robinson Crusoe' was delighted with the print of his bare foot in the wet sand. One boy, who had little interest in the snow prints of sparrows and mice, found that tire-prints had individuality. At home, he learned to recognize those who had made visits, through the marks that were left in the snow by their automobiles.

'INQUIRY INTO THE WORLD AROUND' – THIRD YEAR

To pursue one topic over a longer period of time, and to adhere to a study of interrelated ideas become possible as a child grows older. It will be noted that the syllabus comprises a smaller number of topics than in earlier years.

Topics can be studied more intensively, in part because of the pupil's greater ability to use the resources of printed materials, and in part because of his greater ability to express himself through mathematics and language.

Each topic has its starting-point, a point where the child meets a specific part of the world around him. The teacher's job at the start is to supply surroundings rich in materials and to arrange plenty of opportunities for experience. This may mean taking the children to a row of trees, or bringing magnets and dozens of metal objects into the classroom. For real learning, children must have a great breadth and multiplicity of practical experiences.

Pupils will need time to ask their own questions, to handle the materials, to probe and pry, and talk over what they observe. They will need time to record data, and to gather further ideas from books. Books may suggest fresh techniques and new ways of working. Encouraged by the teacher, each child takes his own part in the process of inquiry.

As the pupil or groups of pupils find out things, there will likely be much discussion. Interpretations will be placed on what was observed, and what was done. Pupils will be looking for patterns in nature. Some of these patterns can be expressed in graphical form and some in numbers and words. Science patterns will be expressed in paper, paint, clay and wood. As pupils discover and portray patterns, they are gaining experience in *organization* – an experience that would be denied them if the organization had already been done for them in the printed or spoken word.

When children in this grade pursue their inquiries, they will probably also find out things in fields other than science. The interrelation between science and mathematics, language, the arts and the other humanities, strengthens learning, and so deserves encouragement. For example, if a child investigating a woodlot unearths a century-old, hand-shaped glass bottle, the teacher would not reject the discovery. He would let the child trace out the origin of the bottle, and encourage him to search out information about the early settlers and their food and drink. Because the teacher is granting the pupil freedom of inquiry he must be ready to accept a breadth of discovery that leads from science into other fields. However, because the starting-points for inquiry are based in Science, much of the discovery will be within that discipline.

SYLLABUS

The following topics are starting-points. The teacher and pupils may extend the studies as desired, may substitute topics of current local importance in place of the suggested ones, and may place the topics in any desired order. Ten topics, or even a smaller number might constitute a year's work, depending on the breadth and depth of each inquiry.

The Woodland

A forest or woodlot is the special field area for extensive outdoor work in this grade. If no natural grove can be visited, pupils might use the trees in a park, trees along an avenue or even a single tree. Much information of descriptive and quantitative nature can result from an outdoor study. Pupils working in groups of various sizes can investigate the tree cover, the animal community living in and under the trees, the soil, and the animals living underground. Woodland field work is rewarding at all seasons of the year.

Variation

The concept that no two individuals are identical can be developed after many practical studies. For example, leaf length can be measured, the number of beans in a pod counted, the number of florets on a chicory head tallied and even the frequency of galls on golden rod plants assessed. Tables, bar graphs and other mathematical expressions are essential in the study.

Bird Life

One species, such as a chicken, redwing, or English sparrow, could be selected for a case study in which the bird would be observed as closely as possible. Alternatively, groups could observe different birds, each studying one species.

Water Drops

As an introduction to the properties of water, several problems can be investigated experimentally. For example, are all drops from a dropper the same size? Do drops on metal foil, waxpaper and glass spread equally? Does water heap differently in a tumbler than other liquids? Is there any pattern in the times taken for water to empty from pop bottles of various size? How high does water rise when a blotter is dipped in it?

Comparing Animals

Animals such as goldfish, a toad, and a cat might be observed in pairs, so as to discover the similarities and the differences. The comparison might be extended to smaller animals which could be examined by individual pupils or groups. (See OISE unit 'Comparing Animals')

Thermometers

Many thermometers will be needed so that the pupils can see the readings easily. Because Centigrade thermometers are graduated in single degrees they are easy to use. Pupils can look for patterns in the changing outdoor temperatures during a day, in the warming of cold water, the cooling of hot water, and the melting of snow.

The Moon

In any month, the moon is present in daytime sky. Pupils might record the time of the observation, the location of the moon and its appearance. Reports in newspapers and periodicals of the findings of moon probes provide further information, and might lead to a study of space vehicles and discoveries in astronomy.

Classification

Classification involves grouping objects into sets and then further dividing each set into sub-sets and so on. Pupils can discover that more than one classification is valid. Geometrical shapes, mixtures of screws and nails, breakfast foods and other materials can be grouped. Keys can be developed. Pupils should be able to use and make simple keys that include only a few items with clearly distinctive characteristics.

Seed Growth

Seeds of flowers, seeds of garden produce, seeds of weeds, and seeds of field crops germinate readily in flats. Pupils will likely set problems for themselves such as, 'Which seeds sprout first? Does every seed grow? How fast do seedlings grow? What happens when a seed is planted upside down?' Topics like this lend themselves to independent inquiry, rather than to 'set lessons'.

Compasses

Pupil experiments with compasses outdoors and in the classroom can lead to concepts of the magnetism of the earth.

Comparing Plants

Pairs of different flowering plants might be observed so that similarities and differences could be listed. Pupils should seek out their own descriptive words suited to the roots, stems, leaves, and flowers. For convenience, much investigation can be made outdoors.

Rain

The observation of raindrops, measurement of rainfall, and investigation of what happens to rainwater may lead to concepts of the water cycle.

SUGGESTIONS

1. The syllabus is brief. It proposes starting-points. Pupils are encouraged to make inquiry in whatever direction they find fruitful, subject to the consideration of safety.

2. Since measurement is required for most topics, it should be introduced whenever the need arises. First, children may use arbitrary units, measuring length with a paper clip or a handspan. Conventional units should next be adopted. Since children find metric units more convenient than others, and since the metric system is becoming more generally used, teachers may wish to introduce this system. For measuring length, only the metre, centimetre, and millimetre are needed.

3. The selected topics may be investigated in any order. In some cases new inquiries may be undertaken by some students while others are completing earlier enterprises.

4. Each child should be encouraged to develop skills through work on projects of his own choosing. Projects requiring on a high degree of skill in classification, such as leaf collection, are of limited value.

5. Since individual pupils may be inquiring into different aspects of a topic, teachers may find a flow chart such as that on page 23 helpful in keeping a comprehensive record of progress.

6. Modern technology provides tools for recording sight and sound. Encourage children to use cameras in class, and on field trips. Tape-recorders are useful in preparing presentations and reports.

7. A large work bench is almost essential for many kinds of creative activity.

8. Children should be encouraged to make predictions once a pattern for a phenomenon is clear, since 'the immediate purpose of scientific thought is to make correct predictions of events in nature.' As an example, in the topic 'Temperature' the outdoor temperature at noon might be predicted after observing the nine o'clock reading. A study of events that have happened in the past often makes it possible to predict events of the future.

'SEEKING THE NATURE OF THINGS' – FOURTH YEAR

The work for this year is largely a continuation of the previous theme, 'Inquiring into the World Around.' As in earlier years, the development of the science program lies in the hands of the teacher in each individual room. He determines the sequence of topics that will best suit his community, based on the syllabus that follows.

SYLLABUS

This syllabus lists several topics to which others might be added. Probably eight or ten topics might be chosen for the year.

Fruits

A study of some fruits of common plants, such as the grape, tomato, pumpkin, wintergreen, cranberry, oak, sunflower, milkweed, and oats will be convenient in autumn. A special search may be made for the fruits forming along a fencerow or in any other habitat that has been chosen for the ecological study.

Common Fish

Pupils may base their studies on small native fish, such as catfish or shiners, that may be observed in aquaria, or on such larger fish as might be secured from a fish store.

Light

Pupils can have practical experiences that may lead to concepts of light as something that travels in straight lines, that may be reflected, that may be absorbed, that may be refracted, that may be divided into colours, and so forth.

Using the Microscope

As the pupil is introduced to the microscopic world, he discovers that the familiar materials, shapes, and surfaces of his environment are frequently composed of smaller units such as fibres, crystals, cells, and so on. Cloth, paper, seeds, sand, soil, salt, moulds, pollen, insect wings, algae, pond life, and anything else pupils bring should be examined through their microscopes. (See OISE unit 'Microscopy'.)

Snow

Since snow on the ground changes from day to day, a continuing field study is possible. The depth of snow layers, temperatures, dampness, texture, penetrability, and other features may be observed by small groups of boys and girls.

Crystals

Children might 'grow' crystals of salt, examine crystals that have developed in rocks, and study such minerals in rocks as feldspar and mica. This topic, with its references to surfaces, edges, corners, and to symmetry links with mathematics.

Insect Behaviour

Mealworms, the larvae of certain grain beetles, are easily reared and fed. To observe these animals and to experiment with them is not difficult. Other insects might be studied instead.

The Burning of a Candle

In studying this phenomenon, groups of pupils might pursue different aspects. Some might study sources of light, others types of fuel, and others combustion and the composition of air. Still others might experiment by burning candles of different size and number in jars of different volume and shape, thereby gaining an insight into 'variables' in an experiment.

Fossils

Local shales and limestones contain fossils which provide a starting-point for study of living things in the past. Museums hold many dinosaur bones of Canadian origin. This topic might lead to a search for reasons why some animals become extinct.

Weight and Matter

Using arbitrary units of weight and volume, the child might investigate such common materials as plasticine, limestone, and iron. The concept of density may be recognized intuitively. (See OISE units 'Matter' and 'Measurement')

Birds and Adaptations

This topic leads to research into adaptations for flight, for survival in winter, for securing food, and for escaping enemies.

The Fencerow Community

A fencerow, grassland, pasture, or even a lawn makes an excellent outdoor laboratory area. Pupils may map the section being studied. In small groups they may measure the population of plants and animals. The kind of soil and subsoil, its temperature and dampness can be noted. Individual pupils may become interested in specialized studies such as the living things under stones, or in stumps.

SUGGESTIONS

1. Children seeking to discover the nature of things should be encouraged to use all the resources they can find. The classroom can function as a laboratory, a library, a study, a workshop, a viewing centre, a discussion hall and a rendezvous for work outside school walls.

2. Outdoor work in the selected field area could extend over a large portion of the year. If a pasture, fencerow or other dry open habitat is not available, a vacant lot or a grassy area at a school might be a suitable location for work.

3. In field work, only the more common living things need be named. The emphasis is on observations and relationships, not taxonomy.

4. Most teachers use a diversity of methods in their teaching. Sometimes teachers encourage open inquiry for which only a starting-point is provided. This is most challenging, because the child must discover a problem, devise a method, and come to findings. Sometimes the topic and problem are given, and the rest is left to the pupil. When the process of discovery is guided more closely, the teacher may choose the topic, the problem, and the method; the pupil then makes the observations that lead to such interpretations and conclusions as seem warranted.

5. Teachers should fit the program to their own schools. The choice of topics depends on the interests of the children, the interests of the teacher, the availability of materials, and the opportunities for useful inquiry.

'SCIENCE SERVING MAN' – FIFTH YEAR

The main theme for the year is that science serves mankind. The ideas that spring from the scientist's search often prove useful in daily life. They help man to cope with the world around him.

The pursuit of science and its application are both creative ventures. In the pursuit of science the scientist attempts to discover the nature of things. He hopes to find some pattern that will describe what he observes. He may call this pattern a concept, a theory, or a principle. These generalizations in science clarify in the mind of man some aspects of the very complex world. The concepts last until some other scientist produces better explanations.

The inventor is the person who creates some new device or some new process for industry. Sometimes he is an artisan, sometimes an engineer, and sometimes a scientist. His invention remains in use until a better product displaces it. Some developments, such as the design of the plow and the domestication of the cow, are ancient, but still important. Others such as the tinderbox are obsolete. But every year new creations of technology are devised in great numbers.

SYLLABUS

Some selection of topics will be necessary; *ten or fewer would be adequate for a year's work.* Topics based on local applications of science and on local industries might be substituted for any listed below.

Man's Use of Water

Especially in metropolitan and larger urban areas, a network of watermains and sewers is necessary. A detailed study of a local water supply might lead back to many operations such as pumping, filtration, purification, storage, and distribution, and to the science underlying these processes.

Wetlands

The year's field area might be a lowland, marsh, or even the edge of a shallow pond. Bogs and deep ponds should be avoided, in the interest of pupil safety. A survey of the plants, animals, and soil might lead in many directions: to the economic uses of wetlands, to the understanding of succession of communities such as the lake-pond-marsh-meadow transition, or to an appreciation of natural resources.

Soil

The upper soil layers, and the associated plants and animals could be examined first. The relation of top soil to farming could be investigated. Pupils might dig a soil pit to observe the soil profile. The importance of the conservation of top soil is apparent when pupils learn how slowly the parent soil changes to subsoil, and the subsoil to topsoil.

Musical Instruments

A practical investigation of the ways in which sounds are produced may be based on examination of various instruments, from harmonicas to pianos. Some pupils may wish to make shepherd's pipes or stringed instruments.

Winter and Man

Pupils might make a practical survey of the effects of winter on the activities of man, and on the world around him. Man has developed technological devices, some to ensure his survival in the cold season, and some to exploit the advantages that winter brings.

The Bicycle, a Creation of Technology

By examining and dismantling a bicycle, pupils may see how the inventor has relied on science, and how artisans have used their skills. Such items as lubrication, air pressure, cogwheels, chrome plate, springs, and chains could be investigated. (In place of a bicycle, a farm implement or a household gadget could be studied.)

Forecasting Weather

The setting up of instruments, the recording of observations and a description of the current weather is a fine pupil activity. Pupils should refer to records from nearby meteorological stations, but they should realize that their

own readings will be somewhat different, if only because the localities are different. Relationship between readings and weather may lead to attempts at forecasting. To forecast weather for even an hour ahead is worthwhile.

Space Travel

Blast-off, trajectory, and re-entry of space vehicles may be simulated with balloons, corkguns and handkerchief parachutes. Pupils should see that the principles underlying the motion of space vehicles have long been a part of daily life, but that the successful operation of the vehicles depends on recent advances in technology.

Domestic Animals

Individual pupils might select one species, such as a cow, horse, dog, hamster, chicken, or duck. The manner of growth of the animal, its characteristics, its wild relatives, and its usefulness could be subjects for inquiry.

Cells and Circuits

Cells, bulbs, switches, electromagnets, buzzers, and other objects can be connected in many ways. Concepts of conduction, insulation, heating effect of an electric current, and magnetic effects may be developed. Some pupils may wish to link Volta, Henry and Edison with their inventions.

The Growth of Plants

The way in which plant stems increase in height and in girth varies with the species. Maples, pines, oats, and beans could serve as examples. A graphical record of the lengthening of the new growth of maples or pines, or a similar treatment of young plants of oats and beans, might reveal interesting growth patterns. Controlled experiments with different conditions of soil, light, water and temperature would lead to the concept of the dependence of living things on environmental conditions.

Insects and Man

Any insect with a local economic importance might receive first study. The tent caterpillar, spruce bud-worm, wasp, black fly, mosquito, and bumble-bee are examples. Since the environment influences its chances of survival, pupils might observe the place in which the insect lives, and also investigate its food, its enemies, and the effect of weather.

Aircraft

Modern aircraft are complex products of modern technology. With the aid of models pupils might begin a study of the theory of flight, the devices for control, and the provision for passenger safety and comfort.

Management of Natural Resources

Conservation is sometimes defined as the wise use of natural resources. Since the topic is extensive, pupils or groups of pupils might choose areas for study such as soil, streams, lakes, wetlands, air, forests, other plant life, and animal life.

SUGGESTIONS

1. Through clippings from newspapers and magazines, news of the most recent applications of science and developments of technology can be brought into the classroom.

2. If tools and scrap materials are available, children can have the opportunity to make models, mock-ups, and simple devices in the classroom.

3. As in earlier years, the topics form starting-points. The activities of pupils and groups of pupils may lead in several directions as shown in the case history chart on page 23. In one class that began a study of 'Space Travel', three projects developed. One group built large models of planets from Styrofoam, another constructed a planetarium dome for use with a commercial star projector, and another group designed a diorama that showed the lunar landscape.

4. Social studies and science could be linked in many ways. For example, the domestication of the horse greatly affected man's way of life.

5. Each topic chosen represents a starting-point for inquiry. No broad survey of the topic is necessary. Only those aspects that seem promising need be studied.

'RECOGNIZING FUNDAMENTAL IDEAS' – SIXTH YEAR

As in earlier years, boys and girls will be making their own observations of the world around them. But science does not stop at observations. Pupils will measure, classify, and interpret what they observe. Eventually they will form generalizations. The generalizations will be directly related to the observations. For example, pupils with a microscope may observe cells in the tissue torn off from the upper side of a leaf and cells in the thin film between the layers of an onion. The simple generalization might be, 'Some plants contain cells.'

Teachers, with their greater background, would recognize that the pupil is discovering one of the fundamental ideas of biology, that the cell is the unit of structure in plants and anmials. This fundamental concept is much more significant than the simple generalization based on the limited evidence. The teacher should alert the class to the important ideas as they are encountered.

Thus, teachers have dual responsibility. First, they should encourage inquiry because it gives experience to the pupils, no matter whether partial or more developed concepts emerge.

Second, they should especially encourage those aspects of inquiry that seem to lead to major concepts.

SYLLABUS

The year's work may be based on the topics listed below, or on others of special local importance. *Ten topics, or fewer, might be selected.*

Case Study of a Tree

Groups of pupils could select different common trees for a long-term study, such as an aspen, a willow, or a lilac bush. The tree would serve as an example of the functioning of a living organism.

The Stream Community

A shallow, wadable brook or creek makes a safe starting-point for an ecological investigation. With sieves, minnow-traps, or hand-held seines, aquatic animals can be caught, and then can be counted and observed closely. The structure of the stream bed and the characteristics of the flowing water could be investigated. The trees, shrubs, and other plants near the stream, the aquatic plants, and the birds, mammals, and other animals living in the surroundings are all part of the stream community. Pupils will find evidence supporting the ideas of fitness for environment, and of interdependence of living things.

Pendulums

Here much practical work is possible because swinging things are common in the child's surroundings. Experiments with suspended pebbles, long sticks and articles of other shapes may lead to data expressed in tables, graphs and words. Fundamental ideas of conservation of energy may emerge.

Origin of Rocks

Local rock structures, or pebbles in brooks and in soil could be examined. A study of sandstone or shale forms an excellent vehicle for underlining the principle enunciated by James Hutton, that events in past geologic history were like events of the present day.

Carbon Dioxide

This is an excellent gas to study because it is comparatively safe and readily produced from vinegar and soda. Pupils may perform experiments to find its relative density, interaction with water, and inability to support burning. The idea of chemical change could emerge.

The Sky at Night

Observation of some constellations, of the planets Venus, Mars, Jupiter and Saturn, and of meteors, may lead to concepts of the earth's motions and of relative distances of celestial objects.

Food Spoilage and Food Preservation

The souring of milk, the fermentation of apple juice, and the growth of moulds make a good introduction to small organisms and to concepts of nutrition in non-green plants.

Machines

Pulleys and levers are machines that lend themselves to practical exercises giving numerical results. Spring balances will prove useful for measuring the force used on the machine.

The Covering of Animals

An examination of the scales of a fish, the skin of toads, snakes, poultry, and mammalian pets, and of the coverings of invertebrates should document any discussion of maintenance of normal body temperature, and of protective colour.

Energy and Work

These quite abstract concepts gain meaning when associated with many concrete examples. Simple apparatus, such as a ball rolling down a trough, or the rebounding of a dropped 'high bounce' ball can be used to illustrate the conversion of energy.

Field Crops

Pupils may select one species of plant, find how it is grown, and from a specimen determine the structure of the root, leaves, stem, and flower. A case study of a cash crop could include its marketing and consumption, so that boys and girls might see links between science and economics.

The Atmosphere

From experiences with tires, barometers, and balloons, pupils can develop such concepts as weight of air, pressure, and the changes in volume accompanying changes in temperature and pressure. The inquiry may lead to a search into the causes of air pollution, to library investigation into the character of the upper atmosphere or to some practical tests for finding the best air pressure for bicycle tires.

THE CLASSROOM AS A WORKPLACE FOR SCIENCE

During the time for science, the classroom becomes the indoor workplace, that is, the laboratory. A steady hum and bustle mark this room where pupils are planning work, assembling equipment, discussing results, and producing booklets, charts and models.

If the teacher decides that facilities should be flexible so that the pupils may work at times in small groups, at times as a whole class, and even at times alone, there is little need for fixed furniture. While there should be at least one large sturdy table somewhere in the room, most of the work will be done at smaller tables, or on two or more desks pushed together. Since pupils will learn by direct personal experience, there is little need for a teacher's permanent demonstration desk. However, a long, low, firm table will have many uses, ranging from a display space for projects to a general workbench.

Pupils will need to handle hammers and saws, and to use tinsnips and pliers. Therefore, a regular workbench with a vise, and a set of simple tools is almost essential. A storage place for lumber, plywood, metal, glass, wire, cloth, paper, cardboard, paints, varnishes, and a diversity of scrap items will keep at hand the wealth of materials that the boys and girls need as they express their ideas.

Running water and sinks are already common in classrooms. Some schools have found that an electric stove, complete with oven, proves a most adaptable source of heat. Others use electric hot plates, gas burners, or candles. For the beginnings of science, it appears that the kind of equipment found at home in the kitchen serves the pupil well at school.

While simple household materials such as kettles, pots, bottles, and saucepans will likely form a large part of the equipment, some scientific apparatus should be purchased in quantity. Magnets and compasses, test tubes and beakers, magnifiers and microscopes, are examples of items that will be much used by many pupils. As a general rule, materials that pupils will use should be secured before materials that can be used only by the teacher.

Since science in the primary and junior divisions is closely linked with other subject areas, there is little need for a room specially designed for science. A classroom that is a good work room for science will prove a useful room for other creative ventures.

THE OUTDOOR LABORATORY

Children have a direct and active interest in everything that goes on in the everyday world around them. They are eager to watch and 'find out' about all the simple things of the home and the street, such as the drains, the making of roads, and the whole cycle of life in animals, in plants, and in the human family.

In many places, pupils make frequent journeys into the larger world outside the schools. To increase the likelihood that all schools may provide opportunities for outdoor studies in science, a plan for visits has been included in the syllabus. A special outdoor area is proposed for each year, so that pupils will meet many different communities of plants and animals. When different habitats are used in successive years there is little danger of a repetition of topics. Dandelions and meadow voles are found in grassy areas, seldom under a woodland canopy. The white trillium is a woodland plant, and would not likely be found by a class investigating wetlands.

First Year – The school grounds and the nearby surroundings.

Second Year – A farm (or a town area for rural children).

Third Year – A woodlot, forest, park, or other treed area.

Fourth Year – A pasture, meadow, fencerow, or other open area.

Fifth Year – A marsh, lowland, or other safe wetland.

Sixth Year – A creek, brook, or other shallow stream.

Clearly, any program for outdoor activities would depend on the variety of landscapes close to the school. Distinctive local features, such as the marine life on James Bay, the flora and fauna of the sand-spits in the Great Lakes, or the relief of the Niagara escarpment, might replace other topics.

Field work should be the vehicle for the development of many topics that are not specifically listed in the syllabus. For example, the concept of adaptation becomes clear through the study of particular cases in which plants and animals are adapted to their environment. Interrelationships between living things, the balance of nature, food chains, and plant succession may also be observed in the field. First-hand experience will support the case for the continued conservation of resources.

Outdoor science programs can be carried out in many ways. Much work can be done in the school grounds, especially where school authorities have been able to provide small field study areas adjoining the playground. Such land laboratories may range from a quarter acre to fifteen acres in size. Some schools own a school forest. Some schools own a farm. Others have agreements allowing access to public or privately owned lands. Some authorities maintain lists of localities to which buses might travel; the lists specify features that might be studied and available facilities. Some authorities have developed school outposts where classes work in the field for a day at a time, and others have built residential schools for outdoor work extending over several days.

Most teachers plan a few longer journeys for field studies in greater depth, as well as more numerous limited trips and inquiries. Frequent trips are desirable, since in every season the field areas will display different features.

APPENDIX A
NEW RESOURCES FROM CURRICULUM GROUPS

In recent years, educational and scientific personnel have collaborated extensively to develop new materials and to encourage fresh approaches to science in the schools. The new materials include booklets, books, equipment, and kits of apparatus that support the practical work in many topics. Most materials have been developed gradually so that each item could be tested, revised, and tested again before being issued for general use. Materials are but part of the product. Each group has developed a rationale which underlies its activities and presents a new approach to science.

O.I.S.E.

In 1963, the Ontario Curriculum Institute named a Science Committee of fifteen members. This group prepared an interim report that assessed the position of science in the schools, and proposed a continuation of the study and development of a curriculum that would have a major emphasis on science as a process of inquiry.

The 1964 Summer Project involved scientists from the universities and teachers from the classroom. Together they developed such units as Matter, Measurement, Microscopy, and Comparing Animals. These units were prepared to lead the students to discover some basic ideas in science. The criterion of success of the units follows: '*If* children could be guided to formulate meaningful problems and to discover by scientific methods of inquiry their own answers, *then* the lessons could be considered successful.'

In succeeding years the O.C.I. Science Committee continued to devlop and test other units, to devise and assemble apparatus for class use, and to introduce many teachers to a new approach in the classroom. The working philosophy of the Committee has been summed up as follows: 'Fundamentally science is a process of inquiry involving the obtaining of data and its critical interpretation, the development of principles, and the recognition of coherence in the data and principles. The teaching of science must involve the student in the processes of inquiry.'

Since September, 1966, the Committee has become a part of the Ontario Institute for Studies in Education (OISE).

O.T.F.

In 1964, the Ontario Teachers' Federation appointed a Science Subject Area Committee of eight teachers. The members gathered data and have already prepared monographs on several themes. The Committee has acted as a task force to do research on several problems in science education, one of which is the field of outdoor education.

A.E.F.O.

In the summer of 1966, a committee of the Association des Enseignants franco-ontariens, an affiliate of the Ontario Teachers' Federation, prepared a series of brochures for teachers of the Junior Division. Each includes many practical suggestions, and proposes teaching methods that are consistent with the new orientation of science in the schools. Pupil activity is stressed: 'Le programme est conçu de façon que les expériences soient faites *par les élèves*. Il est essential que cette directive soit fidèlement suivie pour la réussite du programme.'

E.S.S.

Founded in 1960, the Elementary Science Study has pioneered in developing materials that allow for the flow of ideas originating from the curiosity of children. The units are based on simple things, on concrete materials that are divorced from a technology that frequently becomes outdated. The purpose of the project is not to develop a national curriculum, but to supply a variety of carefully thought-out and tested materials for use in schools. Little emphasis is given toward development of a sequential program with specific structure as to grade level. In 1966, the first five of the ESS units became available from commercial sources.

S.C.I.S.

Since 1961, the Science Curriculum Improvement Study has been exploring a concept of science education based on communicating scientific literacy. It is developing an articulated sequence of studies between Kindergarten and Grade 6. The SCIS program attempts to develop in children's thinking a hierarchical structure of concepts that later become more and more sophisticated.

Each topic represents an application of previous elements of study and at the same time lays a foundation for subsequent elements. The trial edition of 'Variation and Measurement', published in 1964, states: 'the individual lessons are planned to commence threads of thought and inquiry, not to conclude and summarize undertakings.'

A.A.A.S.

In 1962 the American Association for the Advancement of Science appointed a Commission on Science Education which was to have broad concern for science education at all levels. Although its major concern was a development of the curriculum from Kindergarten to Grade 6, the Commission also studies the relation between new course developments in the natural sciences and the social sciences.

The AAAS have developed 'Science – A Process Approach'. The purpose is to develop childrens' skills in the processes of science (classifying, communicating, measuring, using numbers, observing, controlling variables, defining operationally, formulating hypotheses and models, interpreting data, predicting, and so forth), to show how the processes are used, and to allow for experience in using these processes.

By 1965, the Commission had produced the Third Experimental Edition of 'Science – A Process' Approach'. The instructional materials consist of descriptions of exercises so that the teacher can arrange for an orderly progression of learning experiences.

The AAAS program samples widely in subject fields, but little emphasis is placed on the sequence and scope of subject matter. The relation has been stated as follows: 'Science can be thought of as activity and as content, as process and as product. Indeed these two are inseparable and interdependent. The product owes its existence to the process; on the other hand, the process is impossible and also pointless without the product, the knowledge of science'.

NUFFIELD JUNIOR SCIENCE TEACHING PROJECT

In 1964 this project was initiated under the Nuffield Foundation. Its stated purpose was 'to help those who wish to use science as an educational tool in the teaching of children in the age range five to thirteen years.'

The educational practices of the project follow from several premises. First, since children need a great breadth and multiplicity of practical experiences, the teacher's job is to supply an environment rich in materials and with many opportunities for experience.

Second, since children behave naturally in a scientific way the teacher's job is, by discussion, to help them proceed, but not to tell them how.

Third, since the most successful work arises from the questions of children, the teacher's role is to produce situations that will cause questions, and then take up the questions for study.

Fourth, since the real test of a conclusion is whether it fits what is observed, the teacher should help the child to look critically at his work.

Fifth, since children who have observed or discovered something always want to express their discoveries, the teacher's job is to have a good variety of materials available and to encourage its use for the communication of ideas.

Sixth, since children do not see the world in terms of subjects, the teacher's role is to see that science fits snugly into the whole curriculum.

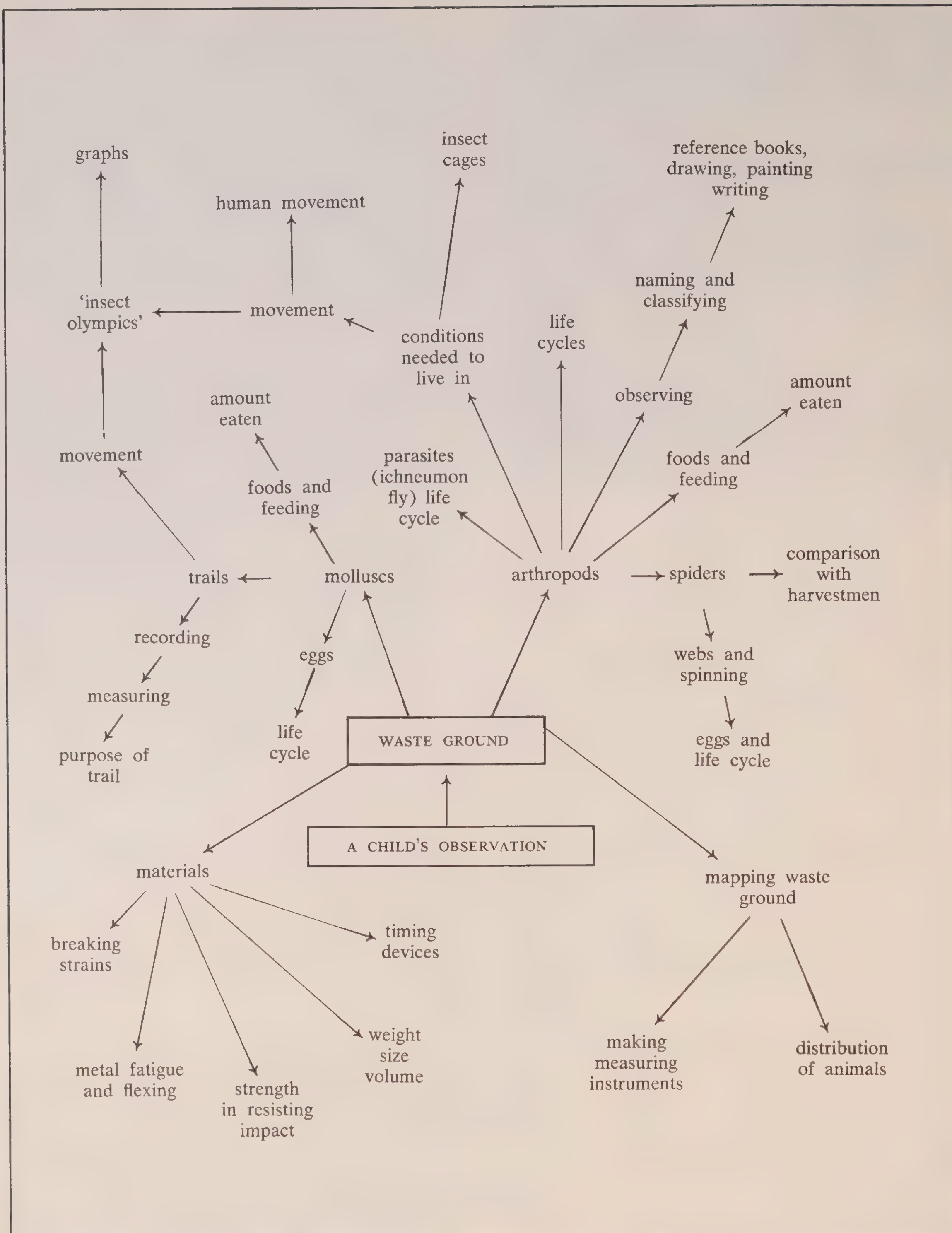
Many other curriculum projects are under way in other countries. These resources of ideas and materials are at all stages of development; some are now available for school use.

APPENDIX B
CASE HISTORY IN THE NUFFIELD JUNIOR SCIENCE PROJECT

The following excerpt is reprinted with the permission of the Nuffield Foundation Science Teaching Project, and is included as a sample of a recent curriculum development in the U.K. It is one of many case histories first printed in the Preliminary Version (1965) of 'Junior Science: Case Histories'.

A STUDY OF URBAN WASTE LAND

Code Number	N.E.8
Class/Age/Ability Range	Age: 9-11 years. Ability: Unstreamed, but very few bright children. Mixed class.
Class Number and School Roll No.	29 80
Building	1900-18. Soon to be demolished.
Classroom	Modern furniture. One electric power point.
School Environment	Urban. Close to heavy industry and gas works. Slum houses all around the school being demolished. Serving slum clearance area.
Local Setting	Industrial area, port; iron and steel making and associated industries; chemicals.


graphs
insect cages
reference books, drawing, painting writing
human movement
'insect olympics'
movement
conditions needed to live in
life cycles
naming and classifying
observing
amount eaten
movement
amount eaten
foods and feeding
parasites (ichneumon fly) life cycle
foods and feeding
trails
molluscs
arthropods
spiders
comparison with harvestmen
recording
eggs
webs and spinning
measuring
life cycle
WASTE GROUND
eggs and life cycle
purpose of trail
A CHILD'S OBSERVATION
materials
mapping waste ground
breaking strains
timing devices
weight size volume
metal fatigue and flexing
strength in resisting impact
making measuring instruments
distribution of animals

HOW THE STUDY BEGAN:

Keith could hardly wait to tell everyone: 'There's a beehive on the common.' They all wanted to see it, so the teacher suggested that they should go and look. Perhaps they might find other interesting creatures. The common is a piece of waste land on which slum houses once stood and which has been colonized by a variety of plants.

They found the bees living in a hole in the wall alongside the railway embankment and after watching them for awhile the children searched for other creatures. They were astonished at the number they found. There were spiders, harvestmen, grasshoppers, wood-lice, slugs, devil's coach horses, crane-flies, leaf beetles, a small white butterfly, a hairy black caterpillar, and many others. In their excitement the children asked few questions, chiefly:

'What is it?'

'Will it hurt me?'

'What does it eat?'

Some of the creatures which were taken into the classroom were housed in aquaria containing soil, stones, and plants; others were put into plastic lunch boxes or cages made from acetate and cheese boxes. Soon the children were absorbed in watching them. A few tried to find their names in reference books; other made simple crude drawings. There was much discussion.

HOW THE STUDY DEVELOPED:

Within a fortnight the children were observing closely and asking many questions. A few began to follow up their questions with experiments, but mostly they continued watching and handling their specimens. They worked alone or in small groups, following their own inclinations and showing little interest in other people. The teacher provided the necessary materials and moved from child to child discussing work and listening to all they had to say.

Brian tried to find out what conditions his devil's coach horse preferred. He covered half of a plastic lunch box with black paper, put the beetle in the centre and watched which way it went. Dennis sloped his container until his bettle remained on the same spot with all of its legs moving, then went on to see which surfaces it could grip easily.

Those who were keeping slugs noticed that their trails made a map of their movements. They dusted chalk on the wet trails to make them easier to see, deciding that white chalk on black paper was best. Stephen first used string to measure the lengths of the trails, but later made a trundle wheel from a cog wheel of an old alarm clock. One night a large slug escaped and crawled twenty-one feet from its cage. Bobby noticed that the trail ended suddenly and the slug was part of the way back along it. He thought that it might be using the trail to find its way home again and tried to test this idea.

The teacher, noticing their growing interest in movement, suggested an 'insect olympics'. Various creatures were timed over one foot and results were shown graphically using match boxes as units. Geoffrey thought the more legs a creature had the faster it could move. When reference to the graph proved him wrong, he wondered whether those with the longest legs could run fastest and tested this idea on his classmates.

Experiments were devised about food preferences. Some were discovered accidentally, as when a devil's coach horse ate an earwig. Others were established by offering a choice. The children calculated the quantity of green leaves eaten by a slug in one day, and in order to see exactly how it ate they mixed some flour and water together, smeared it on a piece of acetate, and watched from below as a slug ate it. Robert announced: 'I know how slugs eat. They kind of scrape,' and was delighted by the scraping sounds made by a large black slug as it ate a leaf.

There were moments of intense excitement when the unexpected happened. Linda and Barbara saw ichneumon fly larvae emerge from a caterpillar and change into cocoons and asked for books to find out more. Dennis was astonished when his devil's coach horse flew across the room. This started him examining other beetles to see if they had wings. Christine watched her slugs lay eggs and wrote her own booklet about it. Experiences like these resulted in discussion, writing, and drawing as the children wanted to communicate their findings.

More slugs' eggs were found and Lynne tried to find the best conditions for hatching. Spiders aroused great interest. Dennis tried to persuade one to eat dead flies. He watched it spin a web and made a coloured drawing of the various stages of construction.

He teased out an egg cocoon, counted the number of eggs and with Barbara made an inch of eggs in order to find the size of one.

The children's work spilled over into their spare time. Carol and Pauline had seen a bee on the common getting nectar by, '. . . sticking its tongue right down into the petals.' Keith said, 'There's a beehive in the museum and you can see the bees going in and out.' Three of the boys made a hive, working from Keith's description, and put it on the common in the hope that bees would use it, but it was destroyed. In any case, Alan had insisted that if they wanted bees to use it they would have to catch a queen and put her in first.

The children noticed that they didn't always find the same number of creatures on every visit to the waste land, so at the teacher's suggestion they agreed to select a number of small plots and study the animal population in each one. They knew that marker pegs would be destroyed, so they measured and mapped the common and showed the position of each plot on a map. They made their own instruments and had to devise methods of fixing a position on the map.

Towards half-term the teacher wrote, 'The children are much more aware of their environment than they used to be, and are constantly discovering objects of interest. Mere identification of a creature will not now suffice.

They wish to know more about the creature and are prepared to go to some trouble to find out. For example, a cockroach was brought in by Norman and Robert. They were arguing about its sex. They remembered that we had a set of pictures showing male and female cockroaches, but nobody knew where the pictures had been stored. They made a thorough search, and with help, unearthed the pictures to confirm Norman's opinion that it was a male. They observe more closely and ask more detailed questions.'

During the second half of the term the children began to gather pieces of waste material from demolition sites. They were spread out on a table in the classroom. The teacher gathered together those who were interested in materials and they discussed them. When he asked them what they wanted to find out about the materials, they were full of ideas. For example:

'Does it bounce?'
'Can it bend?'
'Can it stretch?'
'Will it break?'
'Can you cut it?'
'How heavy is it?'
'How big is it?'
'Can you scratch it?'
'Does it go rusty?'
'What does it feel like?'
'What does it look like under a lens?'

Each child chose a piece of material to examine. Some bent their materials backwards and forwards, others dropped a weight onto pieces of wood resting on two bricks, one or two used spring balances to find the breaking strain of fibres and pieces of rubber. They all wrote.

Following this free investigation they held a reporting session which soon developed into a question time as children asked about problems arising from their experimentation.

Robert: 'Why doesn't rubber float?'
Barbara: 'Why does sponge rubber change colour when it gets wet?'
Brian: 'What is that – like string – made of?' (Part of electric cable.) 'May I look at it through the microscope?'

As each child asked his question, others suggested ways of finding an answer. This marked a change in the children's attitude. Previously they had been absorbed in their own investigations, now they were interested in other people's problems as well and were ready to cooperate.

Their knowledge of materials was put to use as Christmas drew near. Every year, they stretch strings across the school hall and hang decorations. Stephen brought some string but it seemed too thin and weak. They decided to test its strength with a spring balance and found that it needed a 20 lb. pull to break it. They discovered what to do next and many suggestions were offered:

Graham: 'Hold a piece of string at each end, load it with decorations and see if it breaks.'
Alan: 'Put the decorations up and see.'
Lawrence: 'Weigh a quantity of the decorations enough to load one string.'

The teacher said: 'The class decided that Lawrence's suggestion was the most promising, so we followed it. The weight of decoration was only 8 oz. so we went ahead with confidence. As the children moved off to begin hanging up the decorations, Graham remarked that the load would be spread right along each string, therefore, we had extra safety.'

The 'insect olympics' led to an interest in timing, and scrap materials were used to make timers. Sand glasses were made from empty plastic bottles and an unusual timer was made from a metal tube, a wooden block, and a ball bearing. A boy closed one end of the tube, then rested the other end on a block of wood. The ball bearing was placed in the open end of the tube and he could hear it hit the bottom. He altered the position of the block until it took the ball bearing exactly five seconds to travel down the tube. These timers were in constant use.

By the end of the term most of the children had turned their attention to the study of materials and they were determined to carry on with this after the holiday.

OTHER POSSIBILITIES:

1. Plants of waste ground: pollination, nectar, scent, colour; seed production, germination; plant life cycles; adaptation, distribution; interrelationship of plants and animals, food chains; soil studies.

2. Materials: fibres, qualities, strength, elasticity; spinning, spiders and man; resistance to wear, soiling, wetting, staining; shrinking; woven and knitted garments. Body coverings as materials, e.g. fur, feathers, skin, hair. Building materials used by man, wasps, birds.

3. Movement: how animals move, muscles and limbs, centre of gravity, bird flight, fish swimming. Plant movements in response to light, gravity, water, touch. 'Sleep' movements in plants. Moving bodies, friction, lubrication.

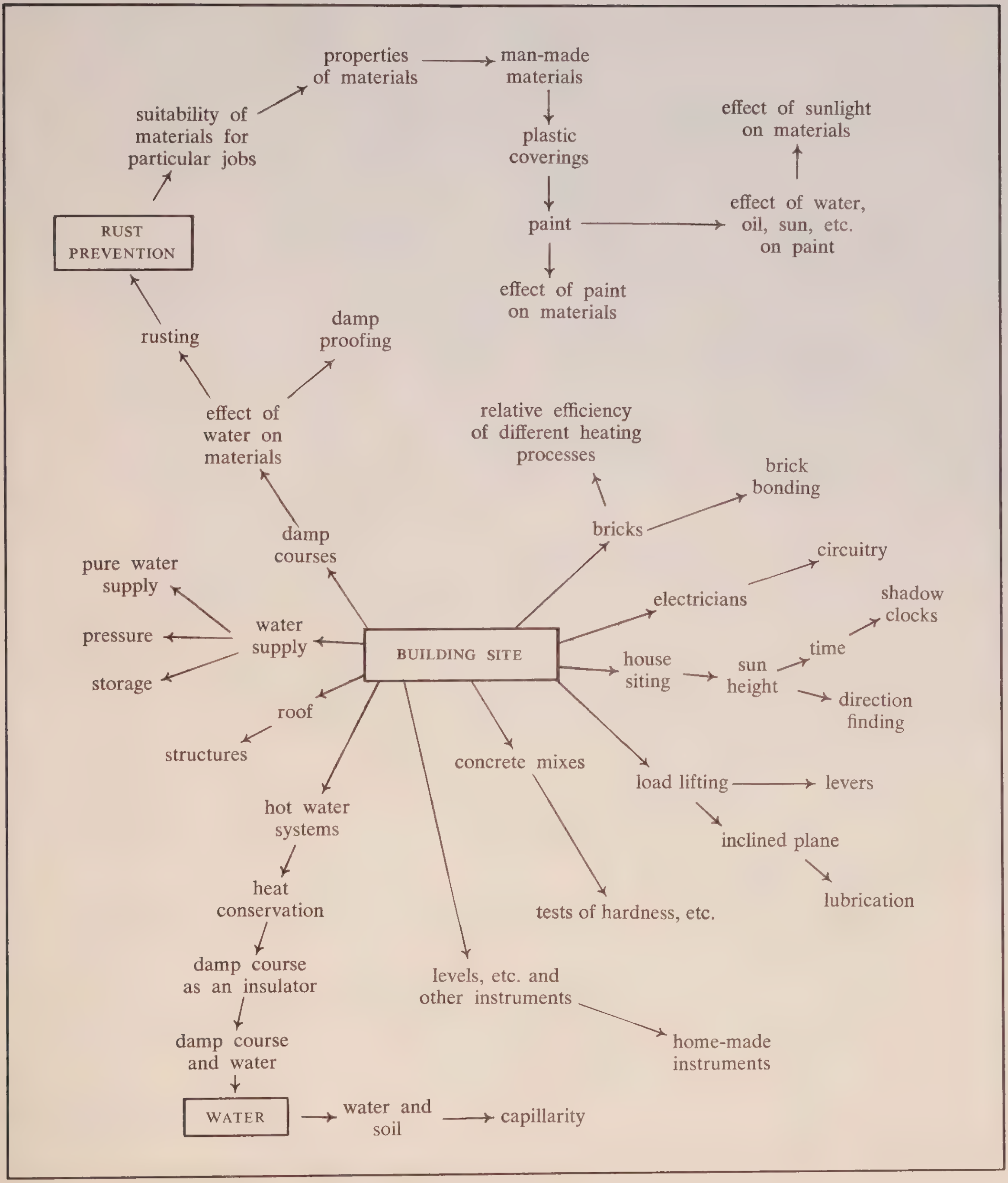
4. Hive bees: keeping observation hive, social life, honey, honeycomb, shape of cells, life cycle, pollen and flowers, over-wintering, hive management, insects and flowers. Characteristics of hymenoptera. Ants as social insects, making a formicarium.

THE SCIENCE WHICH EMERGED:

1. Variety of living things.
2. Animal foods and feeding habits.
3. Animal distribution and adaptation.
4. Life cycles.
5. Animal parasites.
6. Movement.
7. Properties of materials.
8. Breaking strains.

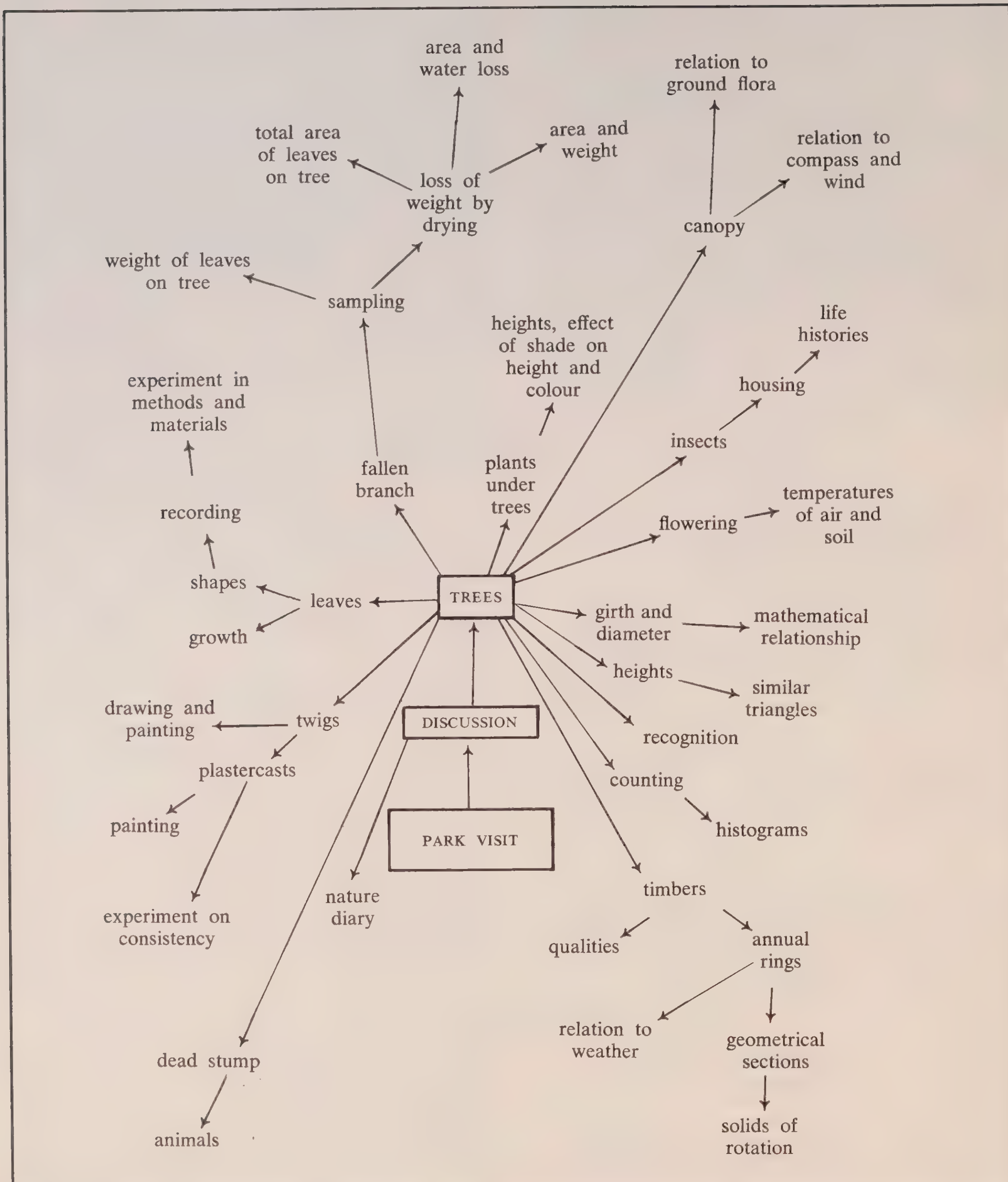
Building Site

This is the first of three extra flow charts to indicate other ventures in the Nuffield Project. This is included to illustrate how an event near the school influenced a program.



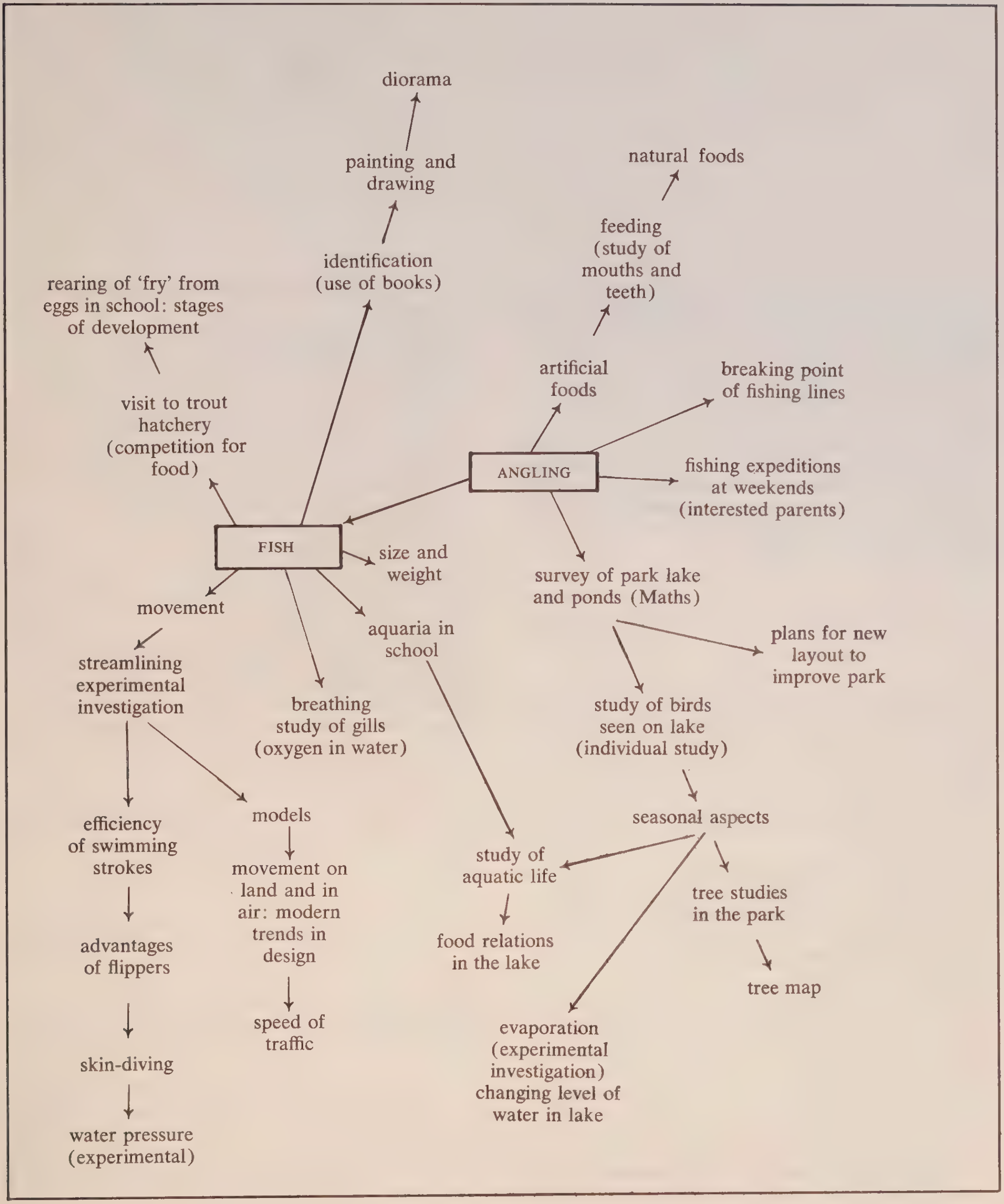
Parkland Study

This flow chart is part of another case history in the Nuffield Junior Science Report. It is included to show the possible links between science and mathematics.



Angling

This flow chart is included to illustrate how a program was based on an interest shown by a group of children.



APPENDIX C
OBJECTIVES

'By educational objectives, we mean explicit formulations of the ways in which students are expected to be changed by the educative process. That is, the ways in which they will change in their thinking, their feelings, and their actions . . .

'Although information or knowledge is recognized as an important outcome of education, very few teachers would be satisfied to regard this as the primary or the sole outcome of instruction. What is needed is some evidence that the students can do something with their knowledge, that is, that they can apply the information to new situations and problems.'

Benjamin S. Bloom
(From *Taxonomy of Educational Objectives: Handbook One*)

The objectives listed below are presented for discussion and consideration. The teacher might determine the degree to which specific items apply to the science program in his own class. The list is not complete, but is representative of the goals and skills that a local committee might set out for a program.

The science program might be expected to develop ability and skill in:

1. observing carefully
2. collecting and organizing data
3. recognizing anomalies and problems
4. delineating and defining problems
5. creating hypotheses
6. making predictions
7. planning experiments
8. devising new equipment
9. controlling variables
10. making inferences
11. interpreting data
12. formulating models
13. describing phenomena
14. forming generalizations
15. recognizing the limitations of generalizations
16. seeking other situations where generalizations are applicable
17. handling materials and equipment
18. describing essential features
19. making operational definitions
20. making graphs, tables and models to present data
21. making interpolations and extrapolations
22. taking samples from a population
23. classifying objects, specimens, and phenomena
24. selecting data from books and other sources
25. expressing ideas in mathematical form

In the course of their science studies, young children will have achieved some progress toward many of these objectives. The particular ones that are associated with each stage of the program will be influenced by such factors as the maturity of the pupils, the characteristics of the local environment, the resources that are available and the selection of topics. If the teacher identifies objectives and plans for them, progress toward goals can be made and recognized. Whenever he tests his work, he can devise testing procedures that will ascertain progress toward these objectives.

APPENDIX D
PRELIMINARY LIST OF SOURCE MATERIALS FOR TEACHERS

1. BACKGROUND READING

DOTTRENS, Robert. *The primary school curriculum.* UNESCO, 1962. 281 p. (Available from the Queen's Printer, Ottawa)

ISAACS, Susan. *Intellectual growth in young children.* Routledge, 1930. 370 p.

LAURENDEAU, M. and A. Pinard. *Causal thinking in the child.* International Universities Press, 1962. 293 p.

LOVELL, R. *The growth of basic mathematical and scientific concepts in children.* University of London Press, 1961. 154 p.

ONTARIO CURRICULUM INSTITUTE. *Science – an interim report of the science committee.* (Available from the Ontario Institute for Studies in Education) 1963. 71 p.

PIAGET, Jean. *The child's conception of physical causality.* Routledge, 1930. 258 p.

WALKER, Marshall. *The nature of scientific thought.* Prentice-Hall, 1963. 184 p.

2. GENERAL CURRICULUM MATERIALS

ASSOCIATION FOR SCIENCE EDUCATION. *Children learning through science, Book 1.* John Murray, 1966. 33 p.

ASSOCIATION FOR SCIENCE EDUCATION. *Materials and equipment, Book 4.* John Murray, 1966. 32 p.

BENNETT, Donald P. and D. A. HUMPHRIES. *Introduction to field biology.* Edward Arnold, 1965. 208 p.

HUG, John and Phyllis J. WILSON. *Curriculum enrichment outdoors.* Harper and Row, 1965. 214 p.

LAWRENCE, E. (editor). *Approaches to science in the primary school.* Published for New Education Fellowship by Educational Supply Association, 1960. 144 p.

NATIONAL SCIENCE TEACHERS' ASSOCIATION. *Ideas for teaching science in the junior high school.* National Science Teachers' Association, 1963. 257 p. (Available from the Association at 1201 Sixteenth Street N.W., Washington, D.C. 20036)

SANKEY, John. *A guide to field biology.* Longmans, 1958. 166 p.

SUCHMAN, J. Richard. *Resource book.* Science Research Associates, 1966. 128 p.

UNESCO. *Source book for science teaching.* UNESCO, 1960. 222 p.

3. SPECIAL SOURCE MATERIALS

AMERICAN GEOLOGICAL INSTITUTE. *Geology and earth sciences source book.* Holt, Rinehart, and Winston, 1962. 496 p.

ASIMOV, Isaac. *Realm of measure.* Houghton Mifflin, 1960. 182 p.

BELL, Corydon. *The wonder of snow.* Hill and Wang, 1957. 269 p.

BITTER, Francis. *Magnets.* Doubleday-Anchor, 1959. 155 p.

CANADA DEPARTMENT OF TRANSPORT. *Weather ways.* (Available from Queen's Printer) 1966. 145 p.

CANADA, NATIONAL FILM BOARD. *The age of flight*. 1966. 4 film strips. (These may be purchased from the Board, P.O. Box 6100, Montreal 3, Quebec)

CANADA, NATIONAL FILM BOARD. *Primary field trips on film*. 1965. 5 filmstrips. (A visit to the pond, garden, farm, seashore, and woods)

COMITÉ DE SCIENCES DE L'ASSOCIATION DES ENSEIGNANTS FRANCO-ONTARIENS (LE). *Projet de sciences: quatrième année,* 1966. 62 p. (Available in September, 1967 from the Association, 60 Boteler Street, Ottawa 2)

COMITÉ DE SCIENCES DE L'ASSOCIATION DES ENSEIGNANTS FRANCO-ONTARIENS (LE). *Projet de sciences: cinquième année,* 1966. 55 p. (Available in September, 1967 from the Association, 60 Boteler Street, Ottawa 2)

COMITÉ DE SCIENCES DE L'ASSOCIATION DES ENSEIGNANTS FRANCO-ONTARIENS (LE). *Project de sciences: sixième année,* 1966. 44 p. (Available in September, 1967 from the Association, 60 Boteler Street, Ottawa 2)

ELEMENTARY SCIENCE STUDY. *Teacher's guide for 'Behavior in mealworms.'* McGraw-Hill, 1966. 56 p.

ELEMENTARY SCIENCE STUDY. *Teacher's guide for 'Gases and airs'*. McGraw-Hill, 1965. 124 p.

ELEMENTARY SCIENCE STUDY. *Teacher's guide for 'Growing seeds.'* McGraw-Hill, 1966. 34 p.

ELEMENTARY SCIENCE STUDY. *Teacher's guide for 'Kitchen physics'*. McGraw-Hill, 1966. 71 p. (For topic Waterdrops)

ELEMENTARY SCIENCE STUDY. *Teacher's guide for 'Small things'*. McGraw-Hill, 1966. 130 p.

FARADAY, Michael. *Chemical history of a candle*. Crowell, 1957. 158 p.

FORD, V. E. *How to begin your field work, Book 1*. Woodland; John Murray, 1959. 47 p.

HARRIS, A. G. et al. *Farm machinery*. Oxford University Press, 1965. 240 p.

HOGNER, B. C. *Farm animals*. Walck (Oxford), 1945. 194 p.

HOLDEN, Alan and Phylis Singer. *Crystals and crystal growing*. Doubleday-Anchor, 1960. 320 p.

KRAYNICK, Steve. *Bicycle owner's complete handbook of repair and maintenance*. F. Clymer, 1953. 126 p.

KUENTZ, Craig. *Understanding rockets and their propulsion*. Rider, 1964. 152 p.

LEMON, R. R. H. *Fossils in Ontario*. University of Toronto Press, 1965. 16 p.

MASON, B. J. *Clouds, rain and rainmaking*. Cambridge University Press, 1965. 145 p.

MEYER, Jerome S. *World book of great inventions*. World Book, 1956. 270 p.

MORGAN, R. F. *Environmental biology, Volume 1*. Pergamon Press, 1963. 238 p.

NATIONAL RESEARCH COUNCIL. *International classification for snow*. National Research Council, Ottawa, 1954. 15 p. (Available from Associate Committee on Geotechnical Research)

NATIONAL SCIENCE TEACHERS' ASSOCIATION. *Investigating science with children, Volume 1 – Living things*. National Science Teachers' Association, 1964. 96 p. (Available from Collier-Macmillan)

NATIONAL SCIENCE TEACHERS' ASSOCIATION. *Investigating science with children, Volume 2 – The earth*. National Science Teachers' Association, 1964. 96 p. (Available from Collier-Macmillan)

NATIONAL SCIENCE TEACHERS' ASSOCIATION. *Investigating science with children, Volume 3 – Atoms and molecules*. National Science Teachers' Association, 1964. 96 p. (Available from Collier-Macmillan)

NATIONAL SCIENCE TEACHERS' ASSOCIATION. *Investigating science with children, Volume 4 – Motion*. National Science Teachers' Association, 1964. 96 p. (Available from Collier-Macmillan)

NATIONAL SCIENCE TEACHERS' ASSOCIATION. *Investigating science with children, Volume 5 – Energy in waves*. National Science Teachers' Association, 1964. 96 p. (Available from Collier-Macmillan)

NATIONAL SCIENCE TEACHERS' ASSOCIATION. *Investigating science with children, Volume 6 – Space*. National Science Teachers' Association, 1964. 96 p. (Available from Collier-Macmillan)

NEEDHAM, J. G. and P. R. Needham. *A guide to the study of freshwater biology*. Holden-Day, 1962. 107 p.

OLCOTT, W. T. *Field book of the skies*. Putnam, 1954. 482 p.

ONTARIO DEPARTMENT OF EDUCATION. *Film Catalogue*. 1965. 367 p. Films listed in the catalogue may be

borrowed from the Audio-Visual section at 559 Jarvis Street, Toronto 5. A representative list follows:

SA- 1 – Animals of the farm
SB-107 – Marsh community
SG- 9 – Fire
SG-100 – Moon and how it affects us
SG-156 – What makes clouds
SG-157 – What makes the wind blow
SG-159 – Energy and matter
SG-160 – How wheels help us
SG-161 – Story of illumination
SG-164 – Science for beginners
SN- 97 – Seasonal changes in trees
SN-147 – Animals, ways they eat
SN-217 – The pond
SP- 11 – The story of the microscope
SP- 22 – Theory of flight
SS-124 – Wonders in your own backyard
SS-291 – Seasons of the year
SS-458 – The dinosaur age

ONTARIO INSTITUTE FOR STUDIES IN EDUCATION SCIENCE COMMITTEE. *Comparing animals*. Ontario Institute for Studies in Education, 1967 (Available from the Ontario Institute for Studies in Education, 102 Bloor Street West, Toronto 5)

ONTARIO INSTITUTE FOR STUDIES IN EDUCATION SCIENCE COMMITTEE. *Matter*. Ontario Institute for Studies in Education, 1967. (Available from the Ontario Institute for Studies in Education, 102 Bloor Street West, Toronto 5)

ONTARIO INSTITUTE FOR STUDIES IN EDUCATION SCIENCE COMMITTEE. *Measurement*. Ontario Institute for Studies in Education, 1967. (Available from the Ontario Institute for Studies in Education, 102 Bloor Street West, Toronto 5)

ONTARIO INSTITUTE FOR STUDIES IN EDUCATION SCIENCE COMMITTEE. *Microscopy*. Ontario Institute for Studies in Education, 1967. (Available from the Ontario Institute for Studies in Education, 102 Bloor Street West, Toronto 5)

ONTARIO TEACHERS' FEDERATION SCIENCE COMMITTEE. *Report*. Ontario Teachers' Federation 1967. (Available after April 1967 from the Ontario Teachers' Federation Office, 1260 Bay Street, Toronto 5.) The report includes these monographs: Astronomy, Birds, Chemistry, Conservation, Energy, Geology, Invertebrates, Machines, Mammals, Plant Growth, and Weather.

PROCTOR, Elsie. *Nature study for primary schools*. Evans Brothers, 1962. 256 p.

RIEHARDS, O. W. *The social insects*. Harper and Row, 1961. 219 p.

SCIENCE CURRICULUM OF IMPROVEMENT STUDY. *Measurement*. Heath and Company, 1967. (Available July 1967)

SMITH, L. P. *Weather studies*. Pergamon Press (Collier-Macmillan), 1963. 100 p.

TRIPPENSEE, Reuben Edwin. *Wild life management, Volume 1 and 2*. McGraw-Hill, 1948.

YOUNGPETER, John M. *Winter science activities*. Holiday House, 1966. 128 p.

4. PROFESSIONAL LITERATURE

CRUCIBLE, published for the Science Teachers' Association of Ontario by the Ontario Educational Association, 3101 Bathurst Street, Toronto 19.

NATURAL SCIENCE IN SCHOOLS, published three times a year by the School Natural Science Society, 8 Sandy Lane, Sevenoaks, Kent, England.

NEW SCIENTIST, published weekly from Cromwell House, Fulwood Place, High Holborn, London W.C. 1, England.

SCIENCE AND CHILDREN, published monthly September through May by the National Science Teachers' Association, 1201 Sixteenth Street, N.W., Washington, D.C. 20036.

SCIENCE TEACHER (THE) published monthly September through May by the National Science Teachers' Association, 1201 Sixteenth Street, N.W., Washington, D.C. 20036.

SCIENTIFIC AMERICAN, published monthly by Scientific American Incorporated, 415 Madison Avenue, New York, N.Y. 10017.